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- The Great Lakes Reborn. Only a decade ago, the Great Lakes were dying from pollution. Now the waters are starting to sparkle again, beaches are reopening, and the big game fish are returning. How did the miracle happen?
- A Matter of Matter. Physicists have been turning up a veritable zoo of particles inside the atom. Now they're chasing the elusive quark, which may be basic to all matter.
- Microsurgeons. How do medicine's explorers of inner space go about reattaching severed arms, legs, hands and feet? Come into the miraculous mini-world of the microsurgeon.
- X-Ray Stars. Aboard a satellite called the Einstein Observatory, a telescope that "sees" X-rays is painting a revealing new picture of a violent universe.
- Hot Waste. What are the newest ideas for disposing of radioactive waste from nuclear plants ... materials that will remain deadly for hundreds of centuries?
- Trains That Fly. Japan will soon have trains that hurtle along at over 300 m.p.h., suspended on a cushion of magnetism.

-- Testing The Unborn. Doctors can now determine the sex and genetic defects of an unborn child, using a test called amniocentesis. But is it safe for the mother and baby?

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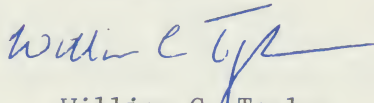
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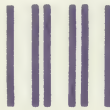
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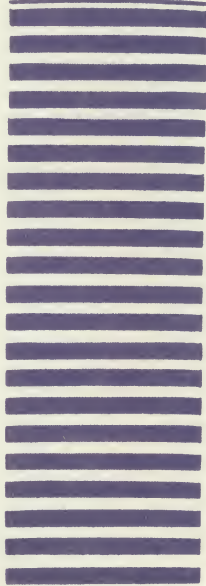
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A photograph of three red-eyed tree frogs (Agalychnis saltator) perched on a branch in a lush green jungle. The frogs have bright green skin with yellow and orange markings on their chests and limbs, and their most striking feature is their large, bright red eyes. The background is filled with out-of-focus green leaves and branches, creating a sense of a natural habitat.

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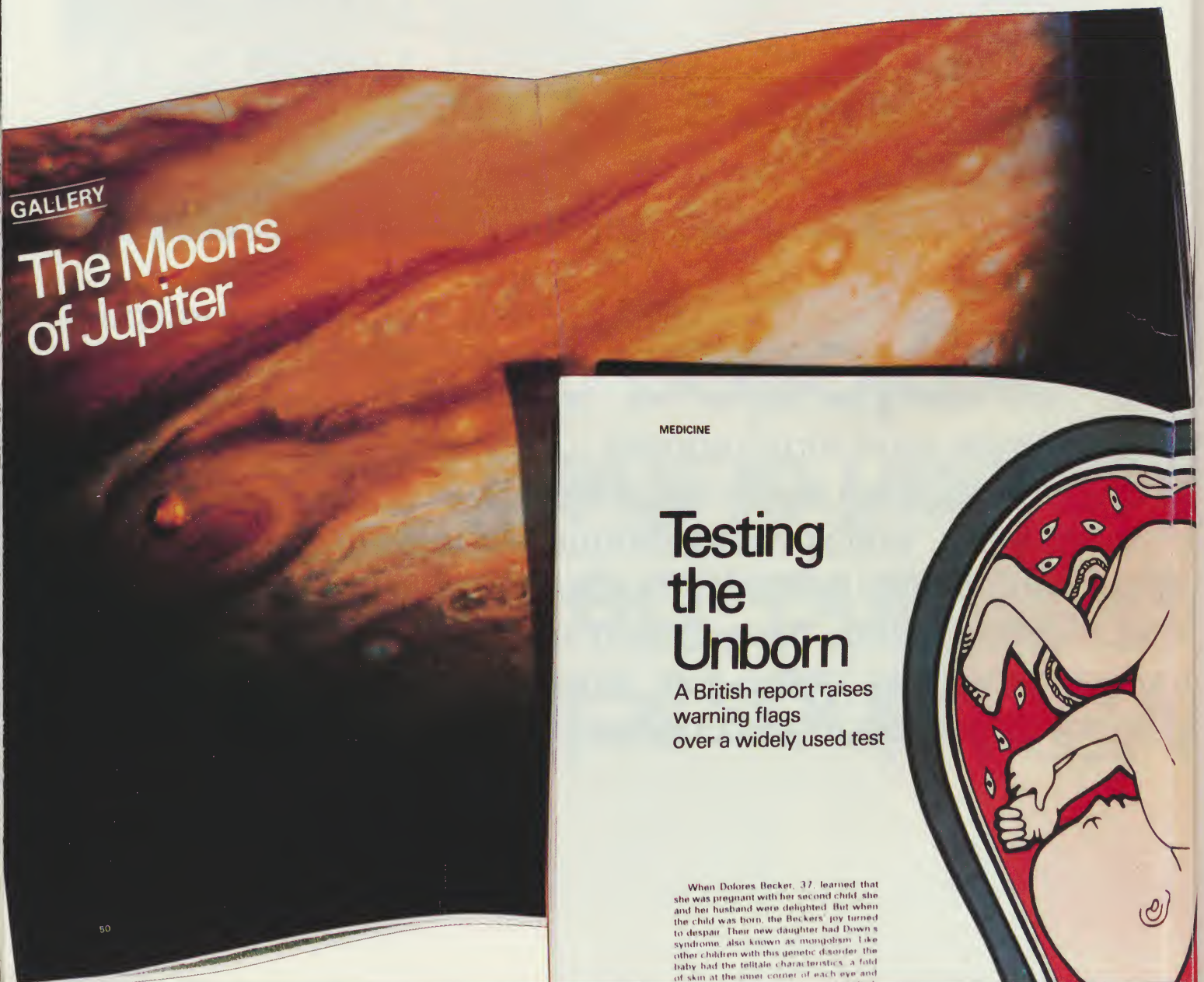
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has remained a closed book to most people. After all, how could you be expected to understand the technical language of the science journals?

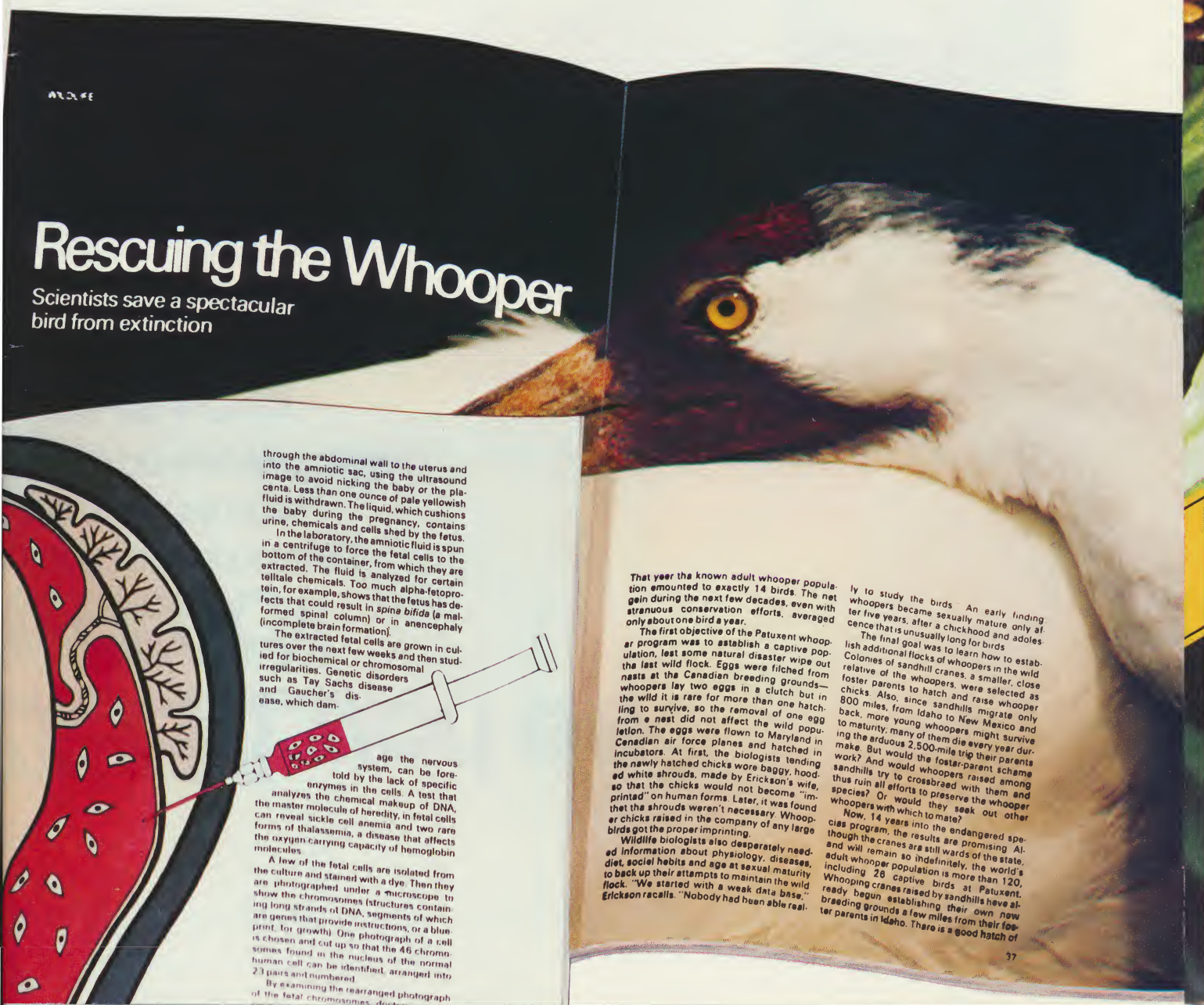
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Rescuing the Whooper

Scientists save a spectacular bird from extinction

through the abdominal wall to the uterus and into the amniotic sac, using the ultrasound image to avoid nicking the baby or the placenta. Less than one ounce of pale yellowish fluid is withdrawn. The liquid, which cushions the baby during the pregnancy, contains urine, chemicals and cells shed by the fetus.

In the laboratory, the amniotic fluid is spun in a centrifuge to force the fetal cells to the bottom of the container, from which they are extracted. The fluid is analyzed for certain toxins, for example, shows that the fetus has defects that could result in *spina bifida* (a malformed spinal column) or in *anencephaly* (incomplete brain formation).

The extracted fetal cells are grown in cultures over the next few weeks and then studied for biochemical or chromosomal irregularities. Genetic disorders such as Tay Sachs disease and Gaucher's disease, which dam-

age the nervous system, can be foretold by the lack of specific enzymes in the cells. A test that analyzes the chemical makeup of DNA, can reveal sickle cell anemia, in fetal cells forms of thalassemia, a disease that affects the oxygen-carrying capacity of hemoglobin molecules.

A few of the fetal cells are isolated from the culture and stained with a dye. Then they are photographed under a microscope to show the chromosomes (structures containing long strands of DNA, segments of which are genes that provide instructions for growth). One photograph of a cell is chosen and cut up so that the 46 chromosomes found in the nucleus of the normal human cell can be identified, arranged into 23 pairs and numbered.

By examining the rearranged photograph of the fetal chromosomes, doctors

That year the known adult whooper population amounted to exactly 14 birds. The net gain during the next few decades, even with strenuous conservation efforts, averaged only about one bird a year.

The first objective of the Patuxent whooper program was to establish a captive population, lest some natural disaster wipe out the last wild flock. Eggs were filched from nests at the Canadian breeding grounds—where whoopers lay two eggs in a clutch but in the wild it is rare for more than one hatchling to survive, so the removal of one egg from a nest did not affect the wild population. The eggs were flown to Maryland in incubators. At first, the biologists tended the newly hatched chicks wore baggy, hooded white shrouds, made by Erickson's wife, so that the chicks would not become "imprinted" on human forms. Later, it was found that the shrouds weren't necessary. Whooper chicks raised in the company of any large birds got the proper imprinting.

Wildlife biologists also desperately needed information about physiology, diseases, diet, social habits and age at sexual maturity, to back up their attempts to maintain the wild flock. "We started with a weak data base," Erickson recalls. "Nobody had been able real-

ly to study the birds." An early finding was that whoopers became sexually mature only after five years, after a chickhood and adolescence that is unusually long for birds.

The final goal was to learn how to establish additional flocks of whoopers in the wild. Colonies of sandhill cranes, a smaller, close relative of the whoopers, were selected as foster parents to hatch and raise whooper chicks. Also, since sandhills migrate only 800 miles, from Idaho to New Mexico and back, more young whoopers might survive to maturity, many of them die every year during the arduous 2,500-mile trip their parents make. But would the foster-parent scheme work? And would the whoopers raised among sandhills try to crossbreed with them and thus ruin all efforts to preserve the whooper species? Or would they seek out other whoopers with which to mate?

Now, 14 years into the endangered species program, the results are promising. Although the cranes are still wards of the state, and will remain so indefinitely, the world's adult whooper population is more than 120, including 28 captive birds at Patuxent. Whooping cranes raised by sandhills have already begun establishing their own new breeding grounds a few miles from their foster parents in Idaho. There is a good hatch of

37

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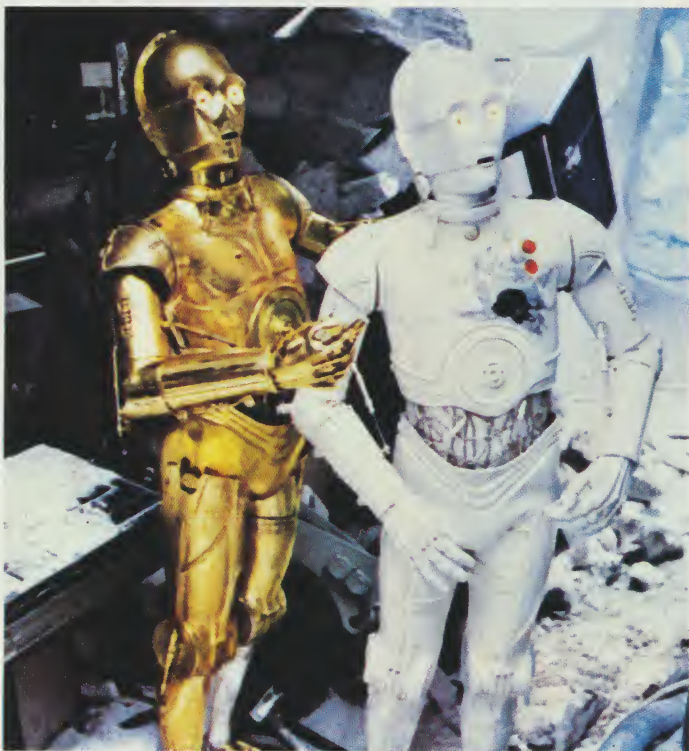
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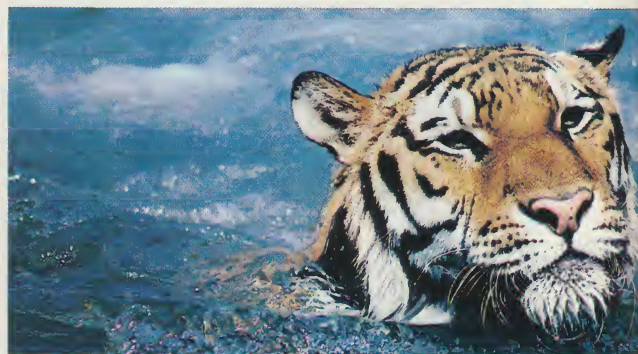
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In *The Empire Strikes Back*, See-Threepio meets a platinum-hued counterpart.



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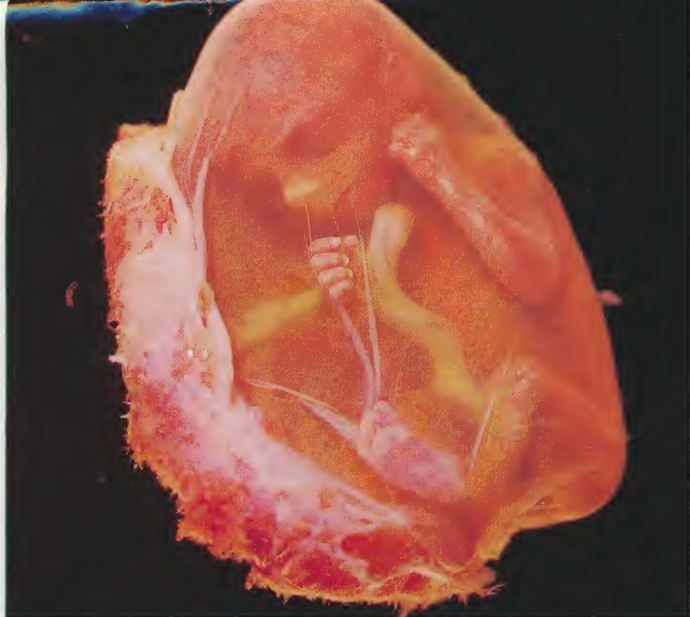


The growing success of limb replantations has increased the demand for microsurgeons.

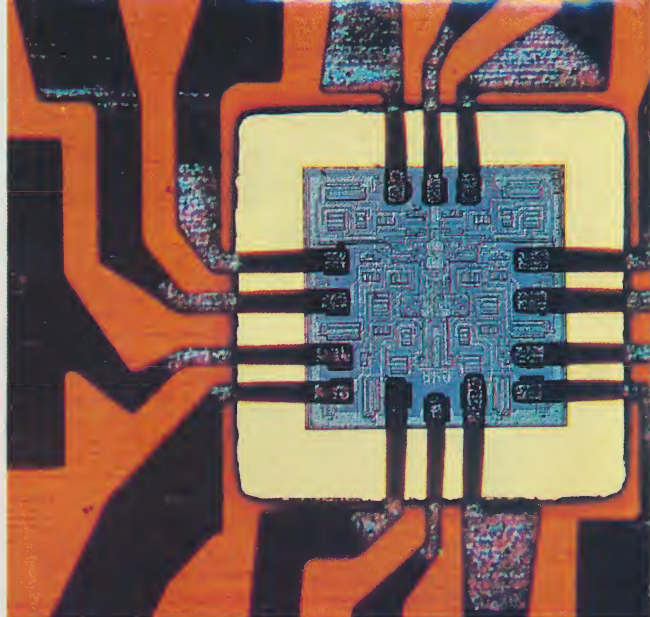


An undersea volcano called "Kick 'em-Jenny" adds new worry to a sailor's list of occupational hazards.

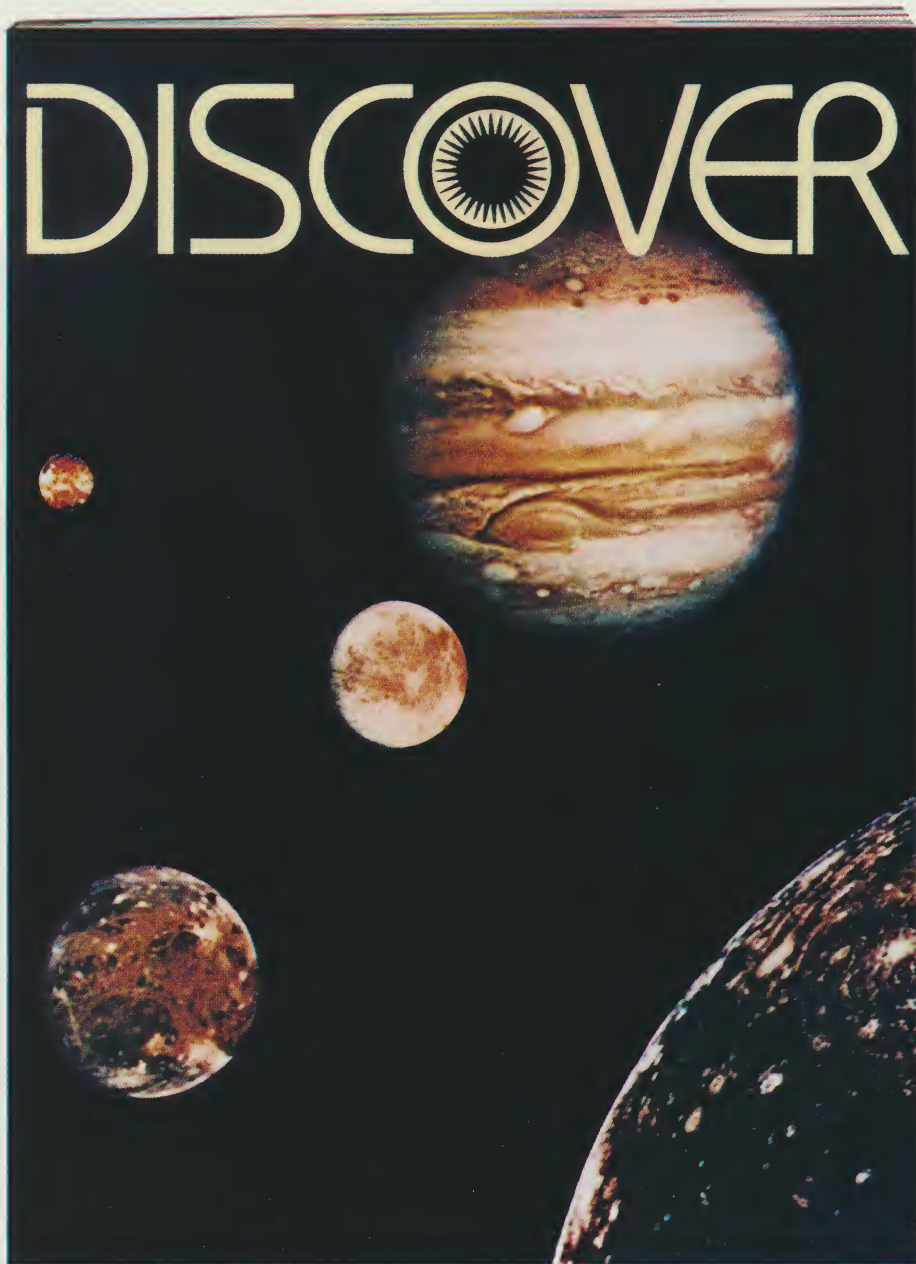
Lennart Nilsson



The sixteen-week-old fetus in this famous shot by Lennart Nilsson is less than six inches long.

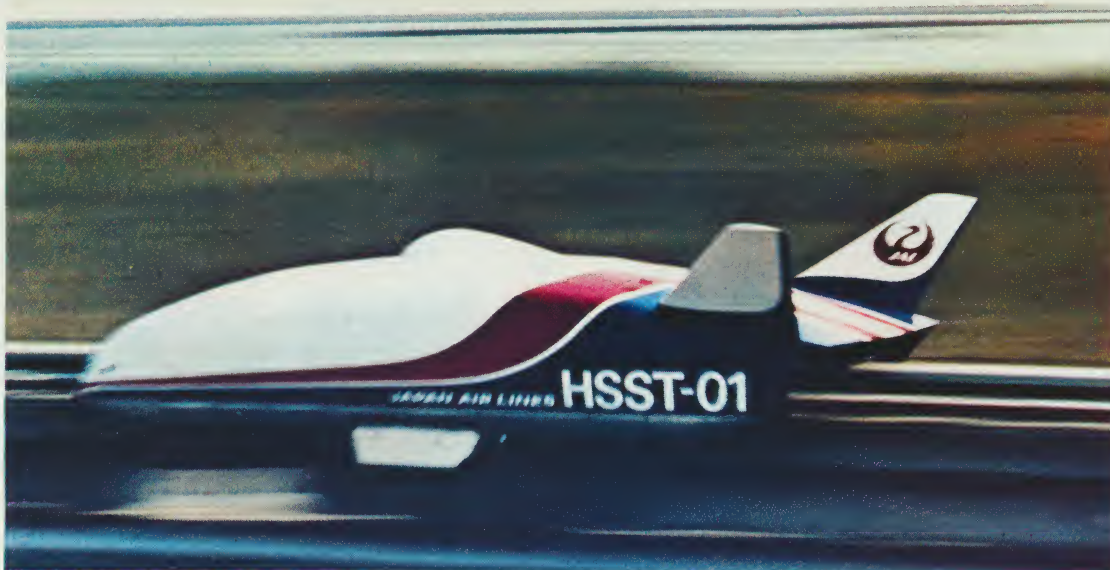


The tiny remarkable micro electronic chip has revolutionized the industry with its ever-growing applications.

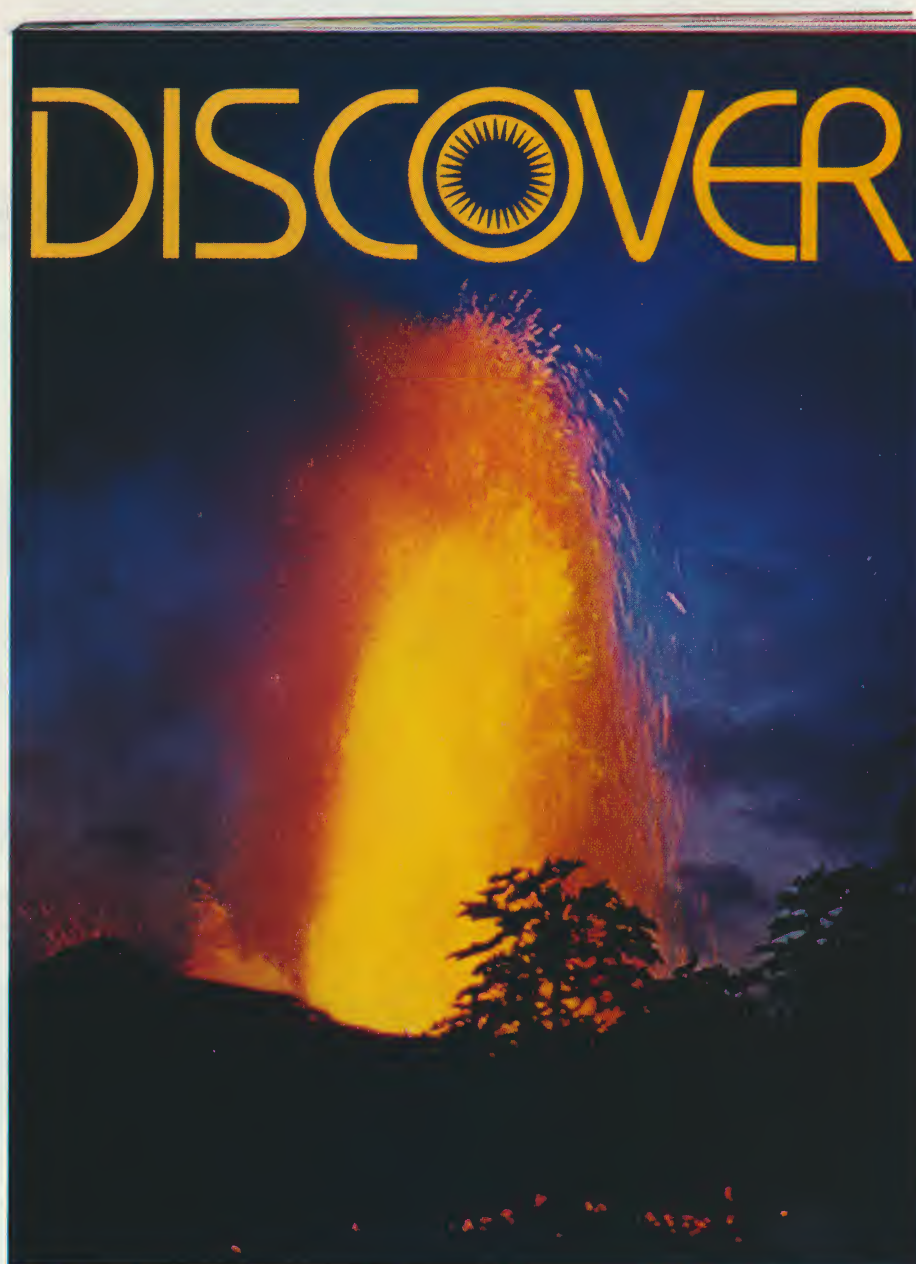




computer



Japanese railroads will soon have trains that hustle along at more than 300 miles per hour, suspended on a cushion of magnetism.



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What's Next for the Nukes

The near disaster at Three Mile Island could be the salvation of nuclear power in the U.S. Just as the tragic Apollo fire that killed three astronauts turned around a moon program floundering in sloppy overconfidence, so can the events near Harrisburg contribute to the building of a nuclear program that is technically sound and better understood by the public.

As the heat continues to dissipate at the damaged Unit No. 2, some tough questions about nuclear power have to be answered with an honest "nobody knows." But even before the final conclusions are in on what went wrong at Three Mile Island, the U.S. must squarely face two facts.

- 1) The nation needs nuclear power.
- 2) Realistic choices have to be made on how much is needed and how to generate it with maximum safety.

Last year, nuclear plants produced 12.5% of the nation's electricity. But utilities have cut back sharply on their once ambitious plans for nuclear expansion, because of the rocketing costs of plant construction, uncertainties about the growth in electrical demand, and regulatory, legal and environmental delays. President Nixon's energy planners foresaw plants supplying 40% of all U.S. electricity by the year 2000. Now, futurists in Jimmy Carter's camp predict no more than 25% (or less than 8% of total U.S. energy consumption)—and there is considerable skepticism that even this more modest goal can be met.

Nuclear power's role in the electrical needs of this country cannot be eliminated without dire consequences. Atomic plants supply about half the electricity in New England, the Chicago area, and parts of the Southeast. Shutting them down would lead to blackouts and brownouts. Electricity bills would soar as utilities were forced to turn to more expensive sources of energy to run their plants. Foreign oil would have to be bought at prices of \$20 a barrel and more, fanning inflation, weakening the dollar, and binding U.S. energy and foreign policy even more tightly to the powderkeg politics of the Middle East. Even M.I.T. physicist Henry Kendall, a leader of the anti-nuclear Union of Concerned Scientists, concedes that "if we throw the switch and shut down all the nuclear plants next Thursday, that would represent a traumatic situation that could not be dealt with by this country."

Before the accident at Three Mile Island, awareness of the possibility and consequences of a core meltdown was, for the most part, restricted to the nuclear and anti-nuclear communities—and to early viewers of the film *The China Syndrome* (see page 86). Now, after press coverage that at times bordered on overkill, every reader and television viewer has some sense of reactor cooling systems and how they can go wrong. More important, the utilities that operate nuclear plants are now all too aware that nuclear reactors are not simple replacements for coal-fired boilers and that the responsibility en-

tailed in operating a nuclear power plant is far greater than that involved with a fossil-fuel plant.

What can be done to provide safe nuclear power for the U.S.? Based on interviews with leading nuclear scientists, *Science Today* proposes the following program:

- 1) Keep the plants isolated.

It is too late to return to the original U.S. policy of building nuclear plants in remote areas such as Hanford, Washington and near Snake River Plain, Idaho. But future construction should be confined to the existing sites that have a minimum of population. Of the nearly 100 nuclear plants now operating or being built, only 13 are on sites that have as many as 25,000 people living within a five-mile radius and only ten where as many as 100,000 persons live within a ten-mile radius. Keep it that way. An area of some 75 square miles around each existing plant should be off limits to further urbanization, that would lessen the problem of evacuation in the event of an emergency. Any new reactors that are built should also be placed at these sites—resulting eventually in a cluster of as many as ten plants in each spot.

- 2) Increase professionalism among the nuclear workforce.

The pilot of a trans-Atlantic 747 is paid about \$100,000 a year, perhaps 50% of what the president of his company receives in salary. The superintendent of a nuclear plant is paid about 20% of what his utility company president gets. The pilot's responsibility for human lives is recognized. But what about the nuclear plant operator? Better pay would attract more highly qualified people, who must also receive better training to achieve the confidence and competence that airline pilots have.

- 3) Separate nuclear generation from distribution.

The nuclear power system requires a strong organization if it is to operate properly. It does not lend itself to small, fragmented operations. Nuclear plants should be run by highly professional organizations set up solely to operate them. In most cases, a cluster site would serve more than one utility. Whether the country is better served by private utility consortiums (heavily overseen by the Nuclear Regulatory Commission) or by a new, public Nuclear Energy Authority to run the plants should be a matter for extensive public debate. The goal, however, would be to separate the responsibilities for generat-

ing nuclear power from the burden of distributing it. Many of the present conflicts of interest could then be eliminated.

- 4) Improve the safety systems.

At one point in the Three Mile Island crisis the experts debated deliberately damaging the cooling system in order to create a problem they had anticipated—and therefore one they believed they knew how to handle—rather than continue to struggle with what was obviously a rising tide of unknown malfunctions in the TMI system. Obviously, plant designers—prompted by stiffer regulations—must think longer and harder about the inherent flaws in any system and anticipate with greater insight what might go wrong. Technically, these complex and unforgiving systems must become more "elegant."

- 5) Educate the public about radiation.

Beyond this is the more fundamental question: Are we building the safest possible type of reactor? The pressurized water reactor design of Three Mile Island was originally conceived to be packed into the cramped confines of a submarine. That it has blossomed into huge central power plants is a source of wonderment to its original designers. Are the British on a safer track with their graphite reactors cooled with gas instead of water? They think so. Canadians moderate their reactors with heavy water. Others, like Alvin Weinberg, former director of Oak Ridge National Laboratory and a leading authority on reactor design, contend that an entirely different type of reactor using fuel in the molten state might provide a plant that is practically immune to a China Syndrome.

"The whole question of low level radiation hazard is so critical to the acceptance of nuclear energy," says Weinberg, "that I would judge this to be a leading, if not the leading, scientific issue underlying the nuclear controversy."

Why is it the public stoically accepts 50,000 automobile deaths and many times that number of disabling, disfiguring injuries each year? If the use of electricity had become widespread in this age of TV nightly news rather than a century ago, would people have greater fears of shock, electrocution and electrical fires? The public must become better informed and place the risks of low level radiation in context with the risks from other products of our technological society.

The nuclear issues are complicated and the stakes high. The outcome will test the ability of a democratic society to solve the most involved technical questions, ones on which experts often offer diametrically opposed opinions. Slogan shouting and rhetoric—"Hell no, we won't glow," versus "Let the bastards freeze in the dark"—are clearly not the way to an energy future that almost certainly must include nukes. Patience, intelligence and ingenuity are.

John Wilhelm
*Water that contains a high proportion of the hydrogen isotope deuterium

Federal Government's new reactor in Idaho (opposite) is first in world designed to stage mock accidents. Anti-nuclear-power demonstrators in Washington (below) protest Three Mile Island accident.



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Hatching New Snails

Called "escargot" when served on a plate, the edible snail can lay 69 eggs during a 36-hour period.



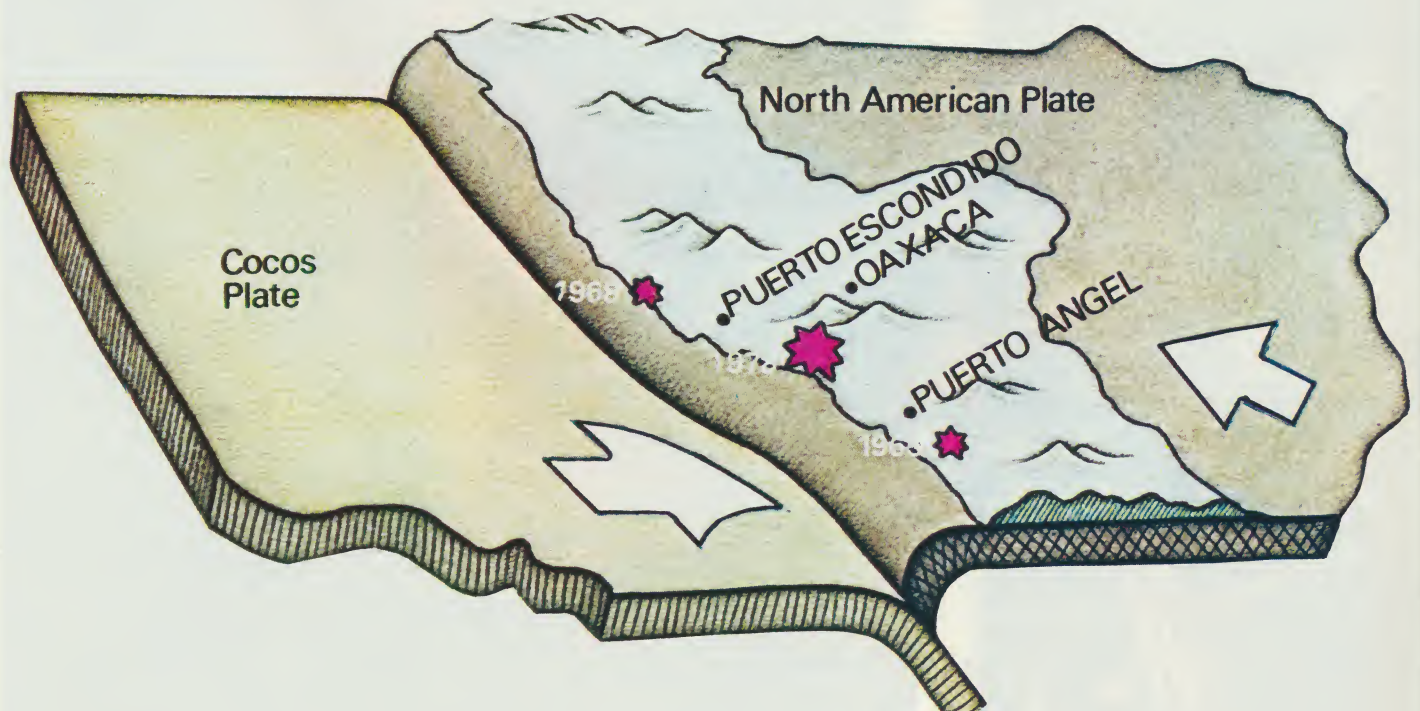


Head Circulation System

The circulatory system of the human head, delineated by polymerized liquid dye.

Forecast: Earthquake

Geophysicists have learned to target future earthquakes by studying geological faults, or the boundaries between tectonic plates.





Masters and Johnson, famous sex researchers, have recently published a major new work, Homosexuality in Perspective.



Psychologist Herbert Terrace, in experiments with his chimp Nim, has cast doubt on claims that apes can master language.



EXHIBIT

Pompeii: A.D. 79

Clockwise from left: artist's conception of the destruction of Pompeii; street corner in Pompeii; portrait of Pompeian couple; house in Pompeii; terra-cotta statue of Pompeian actor; section of mosaic floor; plaster casts of Pompeian couple

Of all the earth's celebrated volcanoes—Soufrière, Stromboli, Krakatoa, Santorini—none is better known than Vesuvius. The towering mountain on the Bay of Naples in southern Italy earned a permanent place in history with a cataclysmic eruption in A.D. 79 that buried the Roman coastal city of Pompeii under an avalanche of ash and mud. Though earthquakes had been occurring frequently, Vesuvius had shown no signs of activity, and the citizens of Pompeii went about their business until it was too late. Their sudden demise, and the destruction of their city, were almost completely forgotten over the next 17 centuries. But ever since excavations at the foot of Vesuvius began to uncover the ruins of Pompeii in the mid-1700s, the life and times of that ancient coastal resort town have become known than those of any city in the Roman Empire. For Pompeii was buried so suddenly and completely that it was preserved virtually intact. It has given archaeologists their only complete example of classical Roman city life stopped in its tracks.

A slice of this life is now being displayed in an exhibit called "Pompeii A.D. 79" at the American Museum of Natural History. During the last two years this collection of wall paintings, sculpture, mosaics, artisans' tools

and handwork has appeared at art museums in London, Boston, Chicago and Dallas—occasionally suffering potshots from critics, who have dismissed it as Roman wallpaper and bathroom tile. Indeed, the artifacts on display do not have great artistic value (most of the best work of Pompeian artists was stolen from the excavation site during the 18th century). But they provide fascinating archaeological detail, and the exhibit presents a lively portrait of this Roman town. As a fascinating companion piece, the American Museum has put together a volcano display that includes movies, photographs, and geological models. In the background is a constant rumbling that sounds like distant artillery but is actually a recording made during Vesuvius' most recent eruption, in 1944.

As the exhibit shows, the volcano that destroyed Pompeii was responsible for creating it. The city's first inhabitants were attracted by the fertile slopes of Vesuvius, where they could plant the olive groves and vineyards that later supported the community's thriving olive oil and wine industries. The exhibit is designed to present several aspects of life in Pompeii, from work and home life to religion. It includes a walk through a luxurious Pompeian

Nineteen centuries ago, Vesuvius destroyed—and preserved—a city.

house, complete with implements and ornaments found in the ruins, that evokes images of Pompeians who seem remarkably contemporary. They liked to surround themselves with color; even middle-class citizens commissioned wall paintings and mosaic floors for their houses. Those who could not afford seaside villas decorated their walls with paintings of them. One popular floor design pictures lobster, prawns, red snapper and bass, which are still favorite catches in the area. Pompeians preferred a few simple pieces of furniture, but no house was complete without a heating urn for mulled wine. The exhibit includes a replica of a garden, with shrubbery, tinkling fountain, and statues of animals, gods and actors.

Ancient Egypt was a favorite theme of Pompeian artists, and some of the city's inhabitants worshipped its gods. The most complete surviving temple of Isis, the Egyptian goddess, was found in this city. Pompeians also swore by good luck charms, and many were adherents of a variety of other religious cults that practiced elaborate rites—some in honor of Dionysus, god of wine. Gladiatorial armor and two erotic paintings from Pompeii's brothels bear witness to more worldly concerns: the city regaled out-of-town visitors with rowdy inns, gambling dens, tav-

erns, and the region's only gladiator fights. At the exit from "Pompeii A.D. 79," faraway artillery grows again—the soundtrack of a continuous film of the 1944 eruption of Vesuvius. So graphic are the images of billowing smoke, collapsing buildings and on-rushing lava that viewers wonder aloud how the cameraman managed to escape with his life. Below the screen, fiery lights play on plaster casts of two creatures who died in A.D. 79—a young woman who tried to protect herself by pulling her tunic over her head, and a chained watchdog twisting in agony on its leash. These and other casts were made by archaeologists from detailed impressions remaining in the dense layer of cinders more than a thousand years after the bodies had decayed. The sight of these victims is startling. Suddenly the exhibit becomes a tangible document of human tragedy, one that could be repeated. Vesuvius has been active ever since the outburst that engulfed Pompeii, and will almost certainly erupt again. This time, the results may be less tragic. Scientists are constantly monitoring seismic activity from an observatory built near the foot of the volcano in 1845, and should be able to give the two million people who live nearby ample warning when Vesuvius stirs again. —Ann Marie Cunningham

